THE INSTITUTE OF PHYSICS

BULLETIN

CONTENTS

Who Uses Scientific Literature — How and Why ? C. W. HANSON 257

A Parent's View of Education NORMAN CLARKE 261

Our Benevolent Fund — What it does and how 264

Notes and News 267

Forthcoming Institute Meetings 267

Correspondence 268

Reviews of Books 269

News of Members 273

The Institute's Journals 275

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THE INSTITUTE OF PHYSICS

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Who Uses Scientific Literature - How and Why?*

By C. W. HANSON, B.Sc., F.I.Inf.Sc.

(*Head of Research, Aslib ; previously Head of the Information Department, British Scientific Instrument Research Association*)

ONE might reasonably assume that the people best fitted to attempt to answer the questions contained in the title are the scientists who read the literature, the editors and publishers of it, and perhaps the authors themselves.

I fall into none of these categories : my writing, editing and publishing has been of secondary literature—abstract journals, digests and reviews, and whilst I have scanned thousands of scientific papers and studied many with care, I have done so nearly always not for my own direct use but on behalf of others. I have been essentially a middleman, and my only excuse for accepting an invitation to talk on this subject is that I think the middleman has an opportunity of seeing in some important respects more than the participants. In particular, he is better placed to observe all-over patterns and trends.

The personal subjective views of middlemen and participants alike, however, have on occasions been shown to be inadequate and sometimes misleading by objective surveys, particularly surveys which have been made of the working habits, and especially the reading habits, of scientists. Since Bernal's classic pilot survey[1] made for the Royal Society Scientific Information Conference in 1948, many have been undertaken. From them, more reliably than from opinions, the faint outlines of a general pattern are beginning to emerge.

According to my reading of the results of these surveys, they suggest, first, that working scientists spend less of their time than has been supposed on experimental work, and more on communication—giving and receiving information in the broadest sense. The results of a recent survey, presented to the International Conference on Scientific Information in Washington last year,[2] illustrate this. The ways in which a large group of chemists spent their working time was studied—directly, not from time-sheets. About 1,300 chemists working in fifty industrial units were observed twice a day, once in the morning and once in the afternoon, for nine consecutive working days. It was found that only about 36 per cent of their time was occupied in experimental work—preparing apparatus, using it, and processing the results. Another 10 per cent was spent on personal and social matters. Communication, of one form or another, accounted for nearly half of their total working day. But only about 7 per cent took the form of reading scientific and technical papers and books. Most of the communication was *personal* communication.

This brings me to an important generalization, which the results of this and other surveys, confirming my own experience, suggest may be valid. It is that personal communication, not reading, is the *preferred* method of acquiring information among scientists and technologists. This seems to be true even among graduates ; among non-graduates the preference is more marked. In fact, only a small proportion of all those whose work is based upon science themselves read original scientific literature. Those without a higher education may have difficulty in understanding and absorbing much of the published material, and above all in applying it to their own work. Others have less difficulty ; but because papers are necessarily written and edited with the common interests or needs of many readers in mind rather than the specific current need of one, each reader has to select from what he has read, and translate it into terms which enable him to apply it to his own problem. So many of them try short cuts first.

An illustration of the low level of the use of literature in small firms with few qualified staff is provided by the results of a survey carried out in several countries by the European Productivity Agency (O.E.E.C.).[3] To take one example, in the United Kingdom 180 small firms in the electrical manufacturing industry—a science-based industry in an advanced industrial country—were questioned as part of the survey. Most of the firms had between 50 and 100, or between 250 and 500, employees. Thirteen per cent of the firms reported that they did not possess any technical book, and 26 per cent subscribed to not more than five periodicals. Forty-seven per cent of them had not consulted a library within the past year.

Graduate scientists and technologists are naturally better equipped to make direct use of the literature than those with a lower level of education, but both usually prefer to get the information they need selected and

* Based on an address given to the Journals Advisory Committee of The Institute of Physics on May 6, 1959.

pre-digested for them, and ready for application, from some other *person*. Their first approach is usually to a person rather than to published material. Their first reaction to a problem is to talk to a colleague, to ring up a friend, to write to someone thought to be an expert in the field, and only later, if at all, to embark upon a search of literature. This procedure is natural enough, and often sensible because it is time-saving : the enquirer gets an answer, not references to published work from which he may be able to extract an answer—but it carries with it the dangers inherent in all second-hand information seeking. Pure scientists and academic workers, for whom the detailed study of the experimental methods reported may be at least as valuable as the results, are less likely to take these short cuts and more likely to study the original literature themselves, even though they may use personal contacts to help them to find the relevant literature.

In general, then, I think there is evidence that except in the academic world personal contact is the *preferred* method of obtaining specific scientific and technical information rather than the search for and personal study of original published work. (The scanning of current periodicals in order to keep up-to-date is common throughout the ranks and is considered later.) If this is true, it is a sobering thought for those concerned with scientific publication. It does not mean, however, that published original scientific literature is of use solely to those who themselves read it. The people who have read it pass on their knowledge to others, often in a form in which the recipient can more easily apply it. It does suggest, however, first, that opportunities for informal and formal personal contacts are important and that as many as possible should be created ; and second, that if original scientific publication is to have its optimum effect among those whose work may be affected by it, it may need to be reissued in simpler form to reach a wider readership. There is much to be said against the publication of several scientific papers written at the same level based upon the same experimental results ; but publication of the same material at different levels may well be desirable.

I have devoted attention first to negative aspects of the matter because I think it important that we should recognize that the study of published literature is only one of the means used by scientists and technologists to obtain information, and probably not the preferred one.

Let me turn now to those, mainly graduates, who do commonly make direct use of scientific publications, and of periodicals in particular. Consider first the readers of current periodicals. We have little knowledge of their number. The editors and publishers of each periodical know how many copies are issued, but this number is, of course, less than the number who read or at least scan each issue : many of the subscriptions are taken out by corporate bodies which circulate periodicals to their staffs and display them in libraries ; and even when the name of an individual appears in the publisher's mailing list the same procedure often applies. When copies are in fact used by a group rather than by an individual, there is evidence from several surveys that each issue will be circulated to and seen by an average of between six and ten people, so that the effective circulation of a current periodical seen by groups of people will be multiplied to this extent.

The reading of current literature is probably the most important single method by which published information is acquired. This current reading is undertaken in order to keep up-to-date—at least that is invariably the reason given for it ; but there is some evidence that the main *effect* is mental stimulation rather than up-to-date knowledge, except in the reader's special field.

In addition to current reading, scientists read material published earlier when specific information is required. In one recent survey the study of non-current periodicals accounted for about one-fifth of the total number of consultations of literature. Often the searchers know the specific papers they think they need to read because these have been cited in books or in current papers, or have been brought to their attention by others. But on other occasions a search, not for a known paper, but for papers on a specific subject must be undertaken. To make such searches effectively one or more of several searching tools must be available. Some of these are :

(1) indexes to volumes of the periodicals in which the searcher thinks papers useful to him will have been published ;
(2) sets of abstracts, with their indexes, thought to cover the subject of the searcher's interest ;
(3) records, such as card indexes, built up by the enquirer or by someone else, e.g. a library, on his behalf in readiness for such a demand.

The effectiveness of the first method depends upon whether the enquirer is right in thinking that the articles he wants will have appeared in a particular periodical, and if he is right, upon the adequacy of its indexes. The young scientist, often unfamiliar with other more sophisticated searching tools, tends to use this method of attack, although it is an uneconomical one unless the literature of a subject is concentrated in one periodical, which is seldom the case.

The second method of approach, through abstract journals, makes it unnecessary for the searcher to know in which periodicals to search : the indexed abstracts enable the searcher to find references to all the abstracted articles on a specific subject within the broader field covered by the abstracts. This is usually the method preferred by the experienced searcher making a methodical search ; but it can only be employed, of course, when long runs of the appropriate abstract journals are available.

The third major searching tool, card indexes, necessarily reflect the indexer's forecast of what will be wanted in the future. In so far as his forecast has been accurate, the card index will provide a rapid and convenient guide to the searcher ; but because it is impossible for the indexer to know for certain what will be useful in, say, five years' time, even the best card index is unlikely to contain all the references which could in fact be useful.

The compilation of indexes, whether on cards or printed for issue with a periodical, is a skilled job worthy of much thought and care ; the absence of an appropriate entry, or the malarrangement of an entry, may make the item to which they refer virtually unfindable

for ever. Much attention is now being devoted to the principles and effectiveness of various methods of indexing and classification, and Aslib is at present engaged on an experimental investigation of the comparative efficiencies of four different systems.[4]

As things stand, the full usage of scientific papers in the years after their publication depends very largely upon whether or not they have been abstracted in one of the leading abstract journals. A 40-year-old paper abstracted at the time in *Physics Abstracts* is more easily findable by a physicist than last year's paper which the abstracting service has missed or deliberately omitted. The publication of abstract journals is, at present, a vital supplement to primary publication. If *Physics Abstracts* did not exist it would certainly be necessary to invent it ! It is essential, both as a tool for retrospective searching and as a means of scanning a larger body of current literature than can be scanned in its original form.

Without the various abstract journals it would be virtually impossible for the searcher to rediscover the literature of the past. And this he must do on occasions. The present volume of current literature is such that few scientists can expect to be able to absorb and remember much more than those papers which have an immediate bearing on their current work, or to record for later use more than a small fraction of those which they think may, at some later date, prove relevant to work they may then be doing.

The extent of the need to consult literature in the years after it has been published varies considerably from subject to subject. It is much less in physics, for instance, than in biology. The matter has been studied indirectly by several workers who have used citations of old papers in current literature to measure the rate of obsolescence of literature, and by others, more directly, who have measured the actual demand for the older literature. Brown,[5] using citations in current literature as his tool, showed that in order to find 90 per cent of the papers in physics cited in papers currently published it was necessary to go back two decades. (The corresponding figure for biology was five decades.) At the British Scientific Instrument Research Association the rate of obsolescence of the periodicals contained in its library was determined by counting and analyzing the loans of back issues. The analysis showed that 10 per cent of the loans were of issues more than thirteen years old, with considerable variations, of course, between individual periodicals. One of the periodicals with the longest useful life was the *Philosophical Magazine*.

It may well be that an editor, immersed in the problems of producing his current issue and planning future ones, tends to underestimate the current importance of what he has published in the past. The sets of bound volumes of his periodical form a vital body of recorded knowledge —knowledge which continues to be used for decades after it was published, provided it is findable. If it is to be findable, adequate attention must be paid to indexing it, and to ensuring as far as is in the editor's power that his papers are abstracted in the appropriate abstract journals, and that the sets of the periodical are available to those who need to consult them in a sufficient number of libraries. The editor's duty to his readers does not end with the production of the current issue, because readers' needs are not confined to current publication.

Who reads scientific periodical literature ? Graduates mostly, for whom it is mainly written ; the others whose work is based on science tend to get their scientific information at second-hand, from those who have studied the literature. How is the literature read ? Mostly currently, as it is published ; to a lesser extent well after it has been published, when it is found by a deliberate search. Why is it read ? Currently, in order to keep knowledge up-to-date, and retrospectively in order to solve specific problems.

These generalizations, so broad as to be platitudinous, only tell part of the story. What weaknesses are there in our present methods of getting scientific knowledge to the people who need it, and how can they be overcome ?

First, we seem to need better ways of getting the information contained in scientific papers to the many people who are unlikely to read the papers in their original form, but whose work may be affected by it. This is a job primarily for the technical and trade press, but can be helped by the publication by learned and professional bodies of simply written monographs on the results and significance of recent work.

Second, we need to make personal communication as easy as possible, because personal communication is for many a preferred form of information gathering and has some inherent virtues. In addition to formal meetings, we need plenty of opportunities for informal talk (the tea break, for instance, may be much more than an amenity) ; and information services should be able to suggest people as well as papers as sources of information.

Third, the volume of current literature is now so great that the amount which can be absorbed or noted for future use by the individual scientist himself is only a small fraction of what may one day be of use to him. He must be able therefore to call upon abstracting, indexing, and library services which will enable him to rediscover papers which he has seen and forgotten when he needs them, and to find others which he has not seen. Such secondary services are nowadays an integral part of scientific publication. In one form or another, they are formally available to many scientists, probably the majority ; but in practice they are not effectively available to many owing to their ignorance of the existence of the services, to geographical location, or to the slowness and complexity of the procedure by which they are used. It is primarily the job of Aslib and others concerned with specialist information and library services to work for improvements in this field.

Fourth, far more factual information is required about the nature of the needs of scientists and technologists for information, so that the facilities for providing it can be well matched to the needs. At present very little data is available about the percentage of needs which can be satisfied, for instance, by a small reference library attached to the laboratories, how frequently a need would be met by any one of several review articles, each providing an adequate introduction to a subject outside the enquirer's field, or how often a detailed methodical search of the whole literature of a subject is necessary.

Finally, there is the question of the primary publication itself—the paper reporting original work published usually in the Proceedings of a Learned Society or the Journal of a professional institution or, with increasing frequency, issued as a "semi-published" report. Present arrangements have been under fire from many angles. It has been suggested that the individual paper rather than the periodical as a whole should be made the unit of publication ; that papers should be shortened to digests for publication, the full paper being available on request ; that refereeing should be stricter and that the author's summaries or abstracts should be subject to more rigorous editorial control. These subjects require separate discussion, and I confine myself here to emphasizing the single point that the semi-published report is no substitute for the openly published and refereed paper if it contains information of lasting value. It seldom bears the authority conferred by refereeing ; it is seldom abstracted, so that its existence often escapes notice ; and even when its existence is known copies may be difficult to acquire.

In this country our methods of disseminating scientific information are still based mainly upon traditions formed when both the accumulated stock of knowledge and the output of new knowledge were very much smaller than now. The methods have been adjusted here and there to meet changing conditions, but until much more factual knowledge has been gathered and analysed we cannot say for certain whether the existing pattern is likely to be appropriate to future needs.

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A Parent's View of Education*

By NORMAN CLARKE, B.Sc., F.Inst.P.

(Deputy Secretary, The Institute of Physics)

I AM supposed to speak as a parent but I do not pretend to speak for all parents; in fact, I speak for nobody except myself, although I hope that most parents would share some of my views.

It has been said that in education everybody is an expert, a remark that is sometimes quoted sardonically by teachers and educational administrators to imply, I suspect, that it is unfortunate that the non-professionals entertain the illusion that they have any right to an opinion, and that educational progress would be more rapid if the professionals were not impeded by politicians, the Church, employers and, above all, parents. I dissociate myself completely from any such view. It is only in the comparatively trivial things of life, such as those which G. K. Chesterton listed as "playing the church organ, painting on vellum, discovering the North Pole, being Astronomer Royal and so on," that experts can safely be allowed to have complete freedom. Like Chesterton, I believe that the really vital things of life are much too important to be left to the experts. Just as war is too serious to be left to the generals, so education is far too serious to be left to the professional educationalists. It is undoubtedly a proper field for pedagogic argument as to how a boy may best be taught to solve a differential equation, assuming that he can be so taught; it requires much more than professional expertise to decide whether this particular intellectual accomplishment or trick shall have any place at all in a boy's education, for one must set its value against the claims of other knowledge—perhaps the philosophy of ancient Greece, or the writings of Saint Augustine, or even the kind of knowledge to which Lord Cherwell was very fond of referring, the amorous intrigues of Louis XV. In some way or other parents should have some share in deciding the purpose, and hence the broad content, of education and, in fact, Section 76 of the Education Act of 1944 requires that "the Minister and local education authorities shall have regard to the general principle that, so far as is compatible with the provision of efficient instruction and training and the avoidance of unreasonable public expenditure, pupils are to be educated in accordance with the wishes of their parents." It is interesting to note that it was thought necessary in Section 114 to define "parent." Teachers are not defined in the Act! By a characteristic, and to some of us even a rather endearing, process of the English political system, this section of the Act is, and always has been, a complete cipher. Every wish of a parent is, by hypothesis, either in complete conformity with that of the local authority or is unreasonable, leading either to inefficiency or to unreasonable public expenditure. But it is at least a triumph that the principle is enshrined in this most important educational statute, even if it has been and, I imagine, was always intended to be completely ignored in practice. As a compromise, perhaps we might have an annual ceremonial reading of Section 76 to solemn assemblies of teachers and professional administrators.

Teachers may think that parents are incapable of seeing the faults of their own children, that they are inclined towards chronic over-indulgence and that they are not always capable of understanding the purpose of education. This is no doubt sometimes true; it may even be that it is often true, and I do not deny that some of the bad features of our present educational system may well stem from ill-informed pressure by parents. Nevertheless, parents—and unfortunately far too few teachers are parents—are often able to see the needs, the weaknesses and the potentialities of their own children with a completeness that is rarely possible for anybody else. Parents are not usually prepared, certainly as far as their own children are concerned, to label children, as administrators and teachers very often are. I have noticed with some disquiet this tendency to label children during this conference. We should remember that the "normal" child is a child with an I.Q. of 100. Much that has been said at this conference would lead one to believe that the "normal" child easily secures admission to a grammar school, probably having an I.Q. higher than 125, and that all the rest, more than three-quarters of the children in this country, are in some way peculiar, and are approached by teachers with some slight distaste. Teachers in grammar schools appear to look with pity upon their colleagues in secondary modern schools, and with more than pity upon those who have to handle backward children. Yet the averagely bright, the dull and the backward children need to be taught. Our educational system exists for them as much as for anybody else. The backward child, to whom most teachers would find great difficulty in offering anything at all, is no more abnormal, no more a freak, than the exceptionally brilliant child at the other end of the spectrum of academic ability. I wish that teachers showed more concern for their collective responsibility to all children, recognizing that our educational system is not intended merely for the academically brilliant child. If the teaching profession cannot give to the children who find academic study very difficult an education that will help to fit them for the world in which they are to live, the profession is failing in a vital part of its task. Many teachers in grammar schools need to acquire a much humbler attitude and a greater sense of service to all children. Purely academic ability, of the kind that is measured in school, plays, and has played, a pretty small part in the history of this world, even in the history of those movements that tend, or have tended, to shape the world for good. Perhaps parents appreciate this fact more clearly than do many educationalists. There are many qualities more important to a child than academic ability, desirable as that ability is.

* An address given to the Conference of the Education Group at the Institute's House, April 3, 1959

The ability to get on with others, with one's future husband or wife and with one's future children ; a predisposition to side with the forces of tolerance, liberalism and humanity; courage; humility; and, above all, an awareness of the enormous richness of the cultural inheritance that we are given—these are the attributes that I should rate most highly. In the interests of our children and of the community, these are more important criteria of successful education than the more easily, and therefore more commonly, applied measuring devices of the academic world. And the children who lack the qualities I have mentioned are by no means always those who are not so good academically.

The special position of the parent, if he is properly fulfilling his responsibility, is that he alone can never claim an excuse for looking at a child as other than a complete person, not as human material to be pushed through an " eleven-plus " examination, to be crammed for five years in a grammar school so that he shall obtain passes in the G.C.E., and to be handed at the age of sixteen to industry to be further tested to decide whether industry's outlay upon his future training will be justified by material results : complete persons, whom it is our responsibility and privilege to try to prepare for the world into which they are going to live.

In this conference we are concerned with children up to the age of fifteen, the age at which most children leave school. Ten years of compulsory education is a pathetically short time in which parents and teachers must prepare a child to enter what one would like to describe as an adult world, but which is unfortunately only a world of adults. I suggest that the place of science or of any other subject in that short period of formal education should be considered primarily in the light of the contribution that it makes to the child's preparation for adult life, set, of course, against the loss inevitably caused by the necessary exclusion of something else. We do not need to enlarge upon the social problems of our day to know how little progress we have made towards fitting children to live in the world into which they are thrust at the age of fifteen or sixteen. We ought to accept the fact that all of us, parents and teachers, are making a most inadequate job of educating children ; what is happening in our world is poor testimony to the efficiency and the sense of responsibility of all of us who are concerned directly or indirectly with education. To assess our effectiveness, it is useless to look at G.C.E. results, or at the pathetically small proportion of boys who succeed in obtaining degrees or Higher National Certificates. Instead, we should study the children of eighteen or nineteen who have been away from formal education for two or three years. Listen to what they talk about on trains and buses, observe what they wear, notice what they read. What values do they consider to be important ? Who are the people that they believe really matter ? In a further two or three years these young people will take their places as fully responsible members of society. I am not very proud of the results of our educational system when looked at in this way, although I am not one of those who merely criticize young people ; they are as good as earlier generations and in some respects a good deal better. Parents have a heavy share of responsibility but if we do not admit that the schools also have a similar responsibility we must draw the inevitable conclusion that the power for good of formal education is trivially small. Few of us would wish to believe that.

It is only up to the age of fifteen that we can make any significant improvement in the general education of children, if only for the reason that about three-quarters of our children leave school at that time. Even for those who go on to further full-time education we now find it necessary to devote time and thought to attempts to develop so-called liberal studies in technical colleges and similar institutions. Something, of course, can be done to develop broader education at that stage, but formal organization of it should hardly be necessary. In any case, liberal education is the responsibility of the schools in so far as it is the responsibility of any educational institution ; if it is the responsibility of the schools, even grammar schools must, in the main, discharge their responsibility before the age of sixteen because some degree of specialization is obviously justified in the sixth form.

" Liberal education " is a common phrase which is usually used without a clear indication of what is meant by it. A liberal education must include knowledge of the material organization of the world in which we live, an aspect which is obviously related to the teaching of science, but I regard the primary purpose of a liberal education as the building of a foundation upon which value-judgements can be made. Value-judgements are the essence of true education because they are the essence of civilization. They are the really difficult decisions of adult life, the decisions that determine the kind of world we have. We do not educate children simply in order that they shall become doctors, lawyers, scientists, butchers or bakers; we educate them because a formal education is believed to be necessary if they are to be able to exercise adult responsibility, to choose effectively between different courses of action, to exercise, for example, the scepticism and the love of veracity which have been spoken about in this conference.

I sometimes hear schoolmasters talking of preparing children for the needs of industry. It is not the primary function of schoolmasters to prepare children for industry, commerce or any other profession or occupation, and I suggest that many leading industrialists would agree with me. Schools should give a liberal education and this, in fact, is in the best sense preparing children for industry. But if it should be necessary, industry must learn how to give the necessary technical knowledge after the schools have made a better job of providing a liberal education. School life up to the age of fifteen is short enough and we have to assign some priorities.

As a parent, what do I expect of the schools ? Firstly, I expect them to co-operate with me as I try to co-operate with them. In other words, I accept my share of responsibility and I am prepared to agree that it is the greater share of responsibility for the education of my children. What I want them to co-operate in is this. I want my children to be able to earn a living but I want them also to have some hope of understanding the world in which they are going to earn that living. I want them to acquire an attitude of mind by which they will appreciate the remarkable inheritance that is there to be

taken. I want them to adopt standards of behaviour and of thought that offer some hope of making the world a better place than it is and a place less likely to destroy itself than would seem to be the case at present. I want my children to be concerned with the glories of our English tongue, with the English countryside and the terrible desecration of it for which we are responsible, with the architectural heritage of our country, with our history and especially the history of the great social and political developments and the intellectual climate in which they have been born, with the world as it is now, dominated outside this country by ignorance, poverty, squalor and prejudice—the world that they have got to live in and with which they must come to terms. I want them to be concerned with ethical standards of behaviour and with the search for truth, not only in science but in morals and religion. I want my children to have some insight into the great potentiality of the human spirit and the enormity of the problems their generation will have to face in the world. I want them to be taught in school, as I hope they may be taught at home, that they must take a stand against self-seeking and materialism, against an *Admass* mentality, against intolerance, persecution and, above all, indifference. It is therefore as people, as men and women, that I judge their teachers, not as people with honours or pass degrees or certificates acquired by two-year courses at training colleges, important as criteria of this kind may be for some purposes. What really matters is the kind of men and women we allow to teach our children, and the kind of moral and intellectual standards they adopt.

Judged against this sort of background, what have science and teachers of science to contribute to a child's education ? As science is taught for school examination purposes, I often feel that it has little or nothing to contribute. I say this despite what I have written and what I have frequently said, that we need to have more education in science. I say it despite the fact that science is increasingly influencing, in some respects dominating, the industrial, political, economic and social aspects of the world into which our children will go. No one can begin to understand our modern world unless he has some idea of what modern science is and what scientists are trying to do : the impact of applied science may be applauded, or it may be deplored, but first of all it has to be understood. Science, too, can be one of the highest flights of the human mind, a great tribute to man's creative imagination, and science, so conceived and so presented, is therefore one of the humanities and a necessary part of a liberal education. All this I believe to be true. But would this view of science be suggested to the boy or girl who is introduced to physics through pins and plane mirrors, density bottles and hot brass weights dropped into small copper calorimeters ? Take up a typical textbook of physics for the Ordinary level G.C.E. and remember that this book is a more advanced scientific book than any that will ever be read by about four-fifths of our population. What picture does this book give of the intellectual magnificence of physics, of a subject that is rapidly changing the environment in which we live ? I would rather see the teaching of science restricted very severely than carried on in the way in which the subject is presented in most grammar schools. Training for most professions begins after the age of sixteen ; we do not teach accountancy or law to children of fifteen, and, at the worst, we could stop the teaching of Ordinary level physics and start the specialist training of physicists and engineers in the sixth form or even after they had left school. If the schools are either unable or unwilling to teach physics as a liberal subject this is what should be done. For the great majority of children, even in the grammar schools, science will never be a specialist study and, therefore, if science is to justify its inclusion before the age of sixteen, it must be a contribution to a liberal education. If it is not taught in this way it has no more right to be in the curriculum of a grammar school than has the technique of wiping a joint. If science is to be taught, then it must be taught in a way that fires the imagination of children with the value and inherent interest of science. It should deal primarily with problems of the real world, not with the fatuous examples of the standard textbooks which often lack any virtue except their previous appearance in examination papers.

Teaching physics as a liberal subject can be done only at considerable cost to the teacher. I doubt whether it can be done at all, except by a handful of gifted people, unless the teacher's own professional experience has been wider than the all too common sequence of school, university and back again to school.

Let me turn to another aspect, already touched upon in this conference and particularly important to me. We have been reminded that scientists are sometimes—and increasingly—regarded as infallible, that science has such a reputation in the modern world that its methods may be thought to be universal and sufficient. Bad science teaching, in which science is taught as a collection of facts, can create such an attitude of mind in the child. One must not belittle observation as a part of science, but the most difficult, most interesting, and most stimulating part of science is that part which is a purely human creation, the assessment of significance in observations, the linking of facts, the finding of relationships between facts in what had hitherto been regarded as quite distinct fields, and the invention of abstract concepts. This is the creative contribution of science that makes it one of the humanities. It is improper emphasis upon the " facts " themselves that can make the teaching of science a deadening influence upon the ability to make moral judgements.

Dr. Bibby in his excellent talk* spoke of the value of science as a means of stressing the importance of veracity, and advanced "observed fact" as our ultimate authority for judgements. " Observed fact," however, takes us only a limited way in life's critical decisions. To which facts of nature would Dr. Bibby have us turn when we have to choose, for example, between Hitler's evaluation of men and the belief that all men are created equal ? I consider it to be crucially important that people should believe the latter, but it is not by any appeal to science that they will arrive at such an opinion. Is it not incomparably more important that the next generation of adults in this country should, for example, understand and believe Thomas Jefferson's view of man as en-

* Published in the September, 1959, *Bulletin*.

shrined in the American Declaration of Independence than that they should be able to pass examinations in physics or anything else ?

Professor C. A. Coulson has commented upon the influence of science teaching, or a misunderstanding of science, upon morality and religion. He says, " every schoolboy knows—or thinks he knows—that modern science has put paid to any serious claims by Christianity to provide an understanding of the world in which we live, and of the people who live in it : for many people science has taken the place of Christianity as the sure and safe ground on which to build a way of life." I agree with Professor Coulson that any method of teaching science which creates such an attitude of mind is a bad method of teaching science. I agree with him that no scientific education is acceptable if it does not incorporate three aspects ; " firstly, that science has its presuppositions, though they are often unrecognized; secondly, science is not based on facts alone, since we have no unfailing criteria for what is either a fact or an adequate proof and, thirdly, that scientific laws develop because there is a considerable personal element inextricably involved even in their formulation."

It is the human basis of science that is so often missing from the teaching of it, especially in schools.† Perhaps if Section 76 of the Education Act were to mean anything, I should be allowed to say that no one would be allowed to teach my children science who did not start from the kind of position I have indicated. I am, however, sufficient of a realist to know that I should merely be beating the air. Most schools may fail to give a liberal education, but they do provide examination successes, and these may be what most people want. I do not deride examinations and I prefer students to pass than to fail, but everything depends on what is examined, how it is examined and by whom it is examined. A discussion of examinations is outside my present subject but no major change is feasible unless the nature and the content of our school examinations in science are radically changed. And hand-in-hand with examination changes would have to go a changed attitude of the teachers (and of most parents) which recognized that teachers are intended to educate and are not primarily employed to beat the examiners.

Three-quarters of the answer to any educational problem lies in the kind of teacher one has. The National Union of Teachers appears to believe that all teachers are "basic" but some are slightly more "basic" than others. On the contrary, there are superb, good, indifferent, bad and thoroughly bad teachers and, in passing, may I give my opinion that these qualities should be reflected in their salaries. It is the quality of the teacher that counts above all else. Teachers are not equal. It is stated, I believe, by the Ministry of Education that every teacher is a teacher of English ; it is no less true that every teacher is a teacher of everything else that a child can learn at school. The overwhelmingly important educational problem of our day is how to attract into teaching enough of those men and women who combine adequate academic competence with outstanding personality and moral worth. Perhaps the second problem is how to get rid of all the rest !

† I recommend all teachers of science to read Michael Polanyi's remarkable book *Personal Knowledge*, especially the chapter on " Intellectual Passion."

Our Benevolent Fund — What it does and how *

" I deeply regret to have to tell you that Dr. X was killed in a motoring accident last week-end. He leaves a widow and three children, aged three, eighteen months and a few weeks."

Fortunately such a letter does not come to the Institute very often ; it is usually from a young physicist's Director or other senior colleague. On its receipt, discreet private enquiries are made to see whether perhaps some immediate help can usefully be given and later to ascertain if the Fund can assist the family to adapt itself to the new circumstances and to help it during the next few years. As regards the first, one has to remember that after such a shock the widow is hardly in a position to think clearly and that funds from the husband's estate, insurances and so forth are not normally available until the various legal and other formalities have been completed. These may take some weeks and in the meantime there are day to day expenses to be met. Very often, a member who is a personal friend, will act as a sort of trustee and a sum of perhaps £25-£100 is put at his disposal to use on behalf of the family, in whatever way seems best. This relieves the immediate worry of where the rent is to come from or the money for the " butcher's and baker's " bills. As regards the longer term difficulties, the aim of the committee is always to " help the beneficiaries to help themselves," and to prevent them developing any idea that they are becoming dependent upon charity. Usually such a widow has been in employment before marriage and can be found some local work, either full or part-time and arrangements made with relations or friends for looking after the children when the mother is out. As the children grow, help is given towards their clothing and keep and a little extra is sometimes found for holidays and Christmas presents. When the children are at school arrangements become easier, especially if they are at boarding school. The Fund Committee

* In order to avoid any possibility of identification, real or imaginary, the cases described here are all fictitious, but are typical of those which the Fund helps.

has laid down, however, that it will not help to send children to expensive fee-paying schools, however much the father may have wished this. The reason is that few of the Institute's members who subscribe to the Fund are themselves able to afford to send their own children to such schools, much as they might wish to, and they cannot therefore be expected to subsidize the sending of other children to them. This decision sometimes comes hard upon a family, but is one of those things which must be faced when it has suffered misfortune. Fortunately it is sometimes possible to obtain special help from the school or from some near relation or friend of the family to carry out the father's wishes.

> " I regret that owing to financial reasons, I must resign from the Institute."

On receiving such a note, the case is looked into and quite often it is found that the member or some near relation is seriously ill or is only slowly recovering from some previous serious illness. It may be six months or a year before he or she can be expected to earn again. Under the powers conferred on it by the constitution, the Board usually remits this subscription and help may be given from the Benevolent Fund in various ways. If a member is in hospital or convalescing a small " pocket money " allowance is made for additional comforts. Or again, if it is the housewife who is ill, money might be found for temporary domestic help. Depending upon particular circumstances, this money is paid (usually quarterly) direct to the family or to a member who is a personal friend of the family and can decide how best to use it.

> " It has come to my knowledge that Dr. X, who retired after many years on the staff of this college, is in some financial difficulty. He would, I believe, be willing to accept an interest-free loan from the Benevolent Fund if such a thing is possible. Could I come up to see you privately about this ? "

This kind of thing arises in the following sort of way. The man, having lived in a rented house for many years, had so arranged matters that the lease expired at about the time of his retirement. He would have saved just enough to purchase a modest cottage in the country to which he and his wife would retire and live economically. Unfortunately, soon after they move into the cottage some serious structural defect is discovered, such as dry rot, which proves costly to eradicate and redecorate —perhaps an additional £1,000 must be found. This could not possibly come from Dr. X's modest pension and rightly he does not wish to draw further on his meagre capital which he regards as his " sheet-anchor " and as some provision for his wife in the event of his predeceasing her. Such a man is generally able to earn a little by writing and examining and may himself suggest that he should pay off the loan over a period of, say, ten years. In special circumstances when such a loan has been granted only a nominal annual repayment is suggested and even that has been overlooked sometimes. Arrangements are however always made to ensure that the amount outstanding can be claimed against the estate on the man's death—provision being made to postpone repayment if he predeceases his wife and she requires the money.

> " Kindly note that my family and I have now returned to this country and are temporarily staying with friends at the above address. You will know of the recent unrest in X which necessitated our being evacuated hastily and having to leave all our property behind. If and when we shall ever recover it I do not know, but we are thankful to be home safely. I should like to come up one day soon to seek your advice about obtaining a new post."

This type of letter comes because of national or racial policies imposed on some oversea education establishments or on other oversea employers. The case suggested here is an exceptional one for reasonable notice has usually been given and at least the member's more personal effects can be brought home or sold, although at a heavy discount. Often, however, pension rights and savings are lost. Usually, immediate temporary help is required until readjustment is possible. Settlement of claims against former employers is a slow and arduous business especially when there are political implications. Each case of this type is dealt with as sympathetically as possible, but the guiding principle is, as always, to help the member to help himself by obtaining a new post as quickly as possible.

> " By the sudden death of my father, my mother has been left very badly off and I am anxious for her to join me here in Australia, where I have just taken up an appointment. Unfortunately, neither she nor I can raise the money for her passage out and she is not eligible to benefit from one of the assisted passages schemes. I wondered if you could make any suggestion as to how we could obtain some temporary financial help."

The Fund Committee may in response to such a request provide the whole of the money for the fare or part of it or arrange to lend the member the money to be paid back over a period of years. The exact decision will depend upon the special circumstances. Thus, if a young man has only recently gone overseas and has not been able to save and in addition has heavy commitments —he may for example have recently married and be expecting his first child—the Fund Committee would probably provide the whole of the money for the fare and not expect its repayment.

> " Please stop sending the *Bulletin* to my husband, who died last month."

Notes like this are received from time to time, usually with a returned periodical or notice of a meeting. The member's papers are sent for from our records section and if it seems possible that the man has dependents, immediate discreet enquiries are made to see if the Benevolent Fund can be of immediate or future help. In some instances the organization for which the member worked have their own Provident Fund to help, and there may be insurances and other benefits to which the dependents might be entitled. Whenever possible, and it is nearly always, the Committee arranges for some colleague to whom the man was well known to " keep an eye " on things and to report if at any time he thinks some additional temporary help might be needed—for example during the illness of a child when

the widow needs to be home and cannot therefore earn, as most of them do.

Applications for help from really destitute physicists are rare. But circumstances do occasionally arise when a member (or even a non-member physicist) comes to the Institute for help. The Secretary has authority to make immediate cash payments of up to £10 in such cases ; but unhappily, however, it is in just such distressing circumstances that it is so often inadvisable to give cash. Rather, one tries to make arrangements for temporary lodgings or for meals until the man can be got into a home of some sort or provided with the necessary medical care which is so often needed.

It is not necessary for decisions regarding applications to wait for one of the regular meetings of the Fund Committee. The Chairman is authorized to act on its behalf between meetings and always does so ; his decisions are reported to the next meeting of the Committee which will decide upon continuing help and what form it shall take. Help from the Fund is by no means restricted to members in the British Isles and mention must be made particularly of the close collaboration of the Honorary Officers of our Australian Branch in helping to administer the Fund in that Dominion.

The Trust Deed of the Fund opens as follows :

> " Whereas the Fellows, Associates and Students of the Institute have established a Benevolent Fund (hereinafter called " The Fund "), having for its sole object the following charitable purposes, namely to help necessitous persons who are or have been Fellows, Associates or Students of The Institute of Physics, whether subscribers to the Fund or not, the wives and children or widows or dependents of Fellows, Associates or Students, or in exceptional cases, to help physicists or their dependents who are not or who have never been Fellows, Associates or Students of the Institute "

(at the time the Deed was drawn there was no Graduate grade in the Institute). The foresight of the founders in including provision for " exceptional cases " has enabled the Fund to give timely help in assisting refugees from persecution to survive and to become rehabilitated.

When assistance is also likely to be received from some other Benevolent Fund, the Institute's own Fund works in close collaboration with it. In such instances the Committee endeavours to channel the help from the different sources through one person in order to avoid the beneficiary having to have his case investigated by more than one person, which might be distressing for a sensitive member.

It is pleasing to record that the gratitude of those who have received help from the Fund is stimulating to all those associated with it. Indeed sometimes a donation is sent by a beneficiary who can ill afford it and its acceptance becomes something of an embarrassment.

In the scheme for amalgamation of the Institute and The Physical Society provision has of course been made for the continuation of the work of the Benevolent Fund.

Many members, realizing that one of the privileges of belonging to a corporate body is to help less fortunate fellow members, are good enough to subscribe annually to the Fund—nearly five hundred of them have signed deeds of covenant which enables the Fund to recover the tax they have made on their annual donations. As will be seen from the annual accounts (published with the Board's annual report in April of each year), the income of the Fund is sufficient at present to meet all the demands upon it. The capital, however, is much too small (only some £6,000) and the Committee is anxious to increase this considerably by putting away some money each year for a " rainy day." It is not, for example, difficult to conceive of a time when employment for physicists (among other professional men) will not be so readily obtainable as at present, especially for middle-aged men. Help during temporary unemployment will certainly be required by some. Again, as the Institute is now about forty years old, requests for help for aged members and their dependents is naturally showing signs of increasing and is likely to continue to do so, particularly if the value of money continues to decrease. It would also be nice one day to follow the excellent example of some of the older and larger professional institutes by providing a home for aged physicists and their dependents. The Fund Committee has already given this matter some thought in recent years, and has investigated various co-operative schemes but cannot at present afford to take any action in this direction.

It is not necessary to add that all cases are considered in strictest confidence and that members should never hesitate to let the Secretary know of any cases that they think might be ones for some assistance from the Fund.

Notes and News

Television lectures

Sir Lawrence Bragg is to give a series of six weekly lectures on television starting on Thursday, October 22. These will be televised from the Lecture Theatre of the Royal Institution and will be the kind of widely comprehensible scientific lectures, with excellent demonstrations, for which Sir Lawrence and the Royal Institution are renowned.

Education Conference in Birmingham

The Midland Branch and the Education Group are arranging to hold a Joint Conference in Birmingham on Thursday and Friday, April 21 and 22, 1960. The subjects to be discussed include the Diploma in Technology, university degrees and postgraduate training. The program with full details will be available in January.

Australian Conference on Automatic Computing

The Australian Branch of the Institute is one of the organizations represented on the Australian National Committee on Computation and Automatic Control which is organizing a conference to be held in Sydney on May 24 to 27, 1960. Papers are invited for consideration and full details may be obtained from C. H. D. Harper, Australian National Committee on Computation and Automatic Control, c/o The Institution of Engineers, Australia, Science House, 157 Gloucester Street, Sydney, N.S.W., Australia.

Forthcoming Institute Meetings

Date	*Place*	*Speaker*	*Title*	*Time*	*Branch or Group*
Oct. 19	**Manchester** The University	Mr. M. G. Rusbridge (*Atomic Energy Research Establishment, Harwell*)	**Thermonuclear research at Harwell**	7.00 p.m.	Manchester and District
Oct. 20	**London** The Institute's House	Dr. F. Kröger (*Philips Electrical Ltd., Eindhoven*)	**The role of chemistry in solid-state physics**	5.30 p.m.	Electronics
Oct. 21	**Hull** The University	Dr. R. A. Smith (*Royal Radar Establishment, Malvern*)	**Molecular amplifiers and oscillators (Masers)**	6.30 p.m.	Yorkshire
Oct. 21	**Birmingham** Exchange and Engineering Centre	Mr. F. Oldham, J.P., F.Inst.P. (*Hinckley Grammar School, Hinckley, Leics.*)	Branch Annual General Meeting followed by a lecture on **Early nineteenth century physics with special reference to Thomas Young**	6.30 p.m. 7.00 p.m.	Midland
Oct. 26	**Aberdeen** The University	The President of the Institute, Sir George Thomson, Hon.F.Inst.P, F.R.S. (*University of Cambridge*)	**Thermonuclear processes**	7.45 p.m.	Scottish
Oct. 27	**Glasgow** The University	The President of the Institute, Sir George Thomson, Hon.F.Inst.P., F.R.S. (*University of Cambridge*)	**Thermonuclear processes**	7.15 p.m.	Scottish
Oct. 29	**London** The Institute's House	Professor G. O. Jones (*Queen Mary College, London*)	**New uses for low temperatures**	6.00 p.m.	London and Home Counties
Oct. 30	**Bristol** The University	Professor J. D. Bernal, F.Inst.P., F.R.S. (*Birkbeck College, London*)	**The structure of liquids**	7.00 p.m.	South Western
Nov. 5	**Bangor**	ProfessorD. J. E. Ingram F.Inst.P. (*University College of North Staffordshire*)	**Electron spin resonance**	5.45 p.m.	Liverpool and North Wales

Nov. 6	**London** The Institute's House	Mr. R. D. Moore, A.Inst.P. (*Guy's Hospital Medical School, London*)	**The role of physics in the investigation and treatment of heart disease**	6.00 p.m.	Non-Destructive Testing
Nov. 6	**Newcastle-upon-Tyne** King's College	Prof. H. S. W. Massey, F.R.S. (*University College, London*)	**The scientific uses of rockets and satellites**	6.15 p.m.	North-Eastern
Nov. 9	**Edinburgh** The University	Mr. R. M. Sillito, F.Inst.P. (*University of Edinburgh*)	**Light waves, radio waves and photons**	7.15 p.m.	Scottish
Nov. 10	**Glasgow** The University	Mr. R. M. Sillito, F.Inst.P. (*University of Edinburgh*)	**Light waves, radio waves and photons**	7.15 p.m.	Scottish
Nov. 10	**London** The Institute's House	Dr. F. C. Champion, F.Inst.P. (*King's College, London*)	**Electronic properties of diamonds**	5.30 p.m.	Electronics
Nov. 11	**Leeds** Physics Department, The University	Dr. D. W. Dewhirst (*University of Cambridge*)	**The nature of the cosmic radio sources**	7.15 p.m.	Yorkshire jointly with the Leeds Astronomical Society
Nov. 12	**Liverpool** Chadwick Laboratory, The University		A social evening. Details will be sent to branch members. Tickets required.	7.00 p.m.	Liverpool and North Wales
Nov. 13	**Exeter** The University	Professor M. H. L. Pryce, F.R.S. (*University of Bristol*)	**Clocks, space travel and relativity**	5.30 p.m.	South Western
Nov. 13 and 14	**London** The Institution of Civil Engineers		Conference on **Structure analysis** and **Apparatus and experimental techniques**	10.00 a.m.	X-ray analysis
		Professor P. P. Ewald, F.Inst.P., F.R.S. (*Polytechnic Institute of Brooklyn, U.S.A.*)	Evening discourse on **Crystallography in the past and the future**	8.00 p.m.	

Registration is necessary. Full details may be obtained from the Secretary of the Institute.

Correspondence

Since we are periodically engaged in setting and marking examination questions ourselves, we always study with interest the published papers set in the Graduateship examination and also the comments by the examiners. We are also thankful that ours are not subject to the same degree of public scrutiny.

We wish to comment on question 3 in this year's Physics II paper.

In his comments, Professor Lipson states that credit was given for simplifying assumptions introduced to solve the question. He also states in his letter (*Bulletin*, Feb. 1959, p. 38, and referred to in his comments) that " the examiner should be able to recognize sound physics when he sees it. If an answer contains demonstrable nonsense . . . it is given poor marks ; if it contains as much as I know myself, it is given reasonably good marks; but if it contains more than I can judge, and I have to check the reply against the textbooks . . . it is likely to gain very good marks."

The wording of question 3 and the comments of the examiner suggest that the problem is essentially one of " heat conduction across a solid of which one face was not at a constant temperature." A solution based on this assumption only is " demonstrable nonsense " since the effective thermal conductivity of water, which is not given, is very small compared with that of lead unless turbulent flow is present. As a result, a solution requires the knowledge of heat transfer and fluid flow under turbulent conditions, subjects not normally expected in Physics II.

We would be interested to learn the " sound physics " on which the examiner's solution is based.

W. K. Mansfield (*Associate*)
R. F. Saxe (*Associate*)
Queen Mary College,
Mile End Road, London, E.1

The examiner, Professor Lipson, comments :

I think it best to reply by stating more explicitly than I could in my comments what answer I wanted. The problem is primarily one of radial flow, but a simple

problem of this type would have been unsuitable. I therefore introduced some variation. The water comes in at 5°C and leaves at 0°C. What is the variation of temperature along the length ? The candidate, having dealt with the radial-flow theory, then finds that this problem is too difficult and that he must make some plausible assumption such as a uniform temperature gradient. He can then work out the rate of passage of heat across the thickness of the tube, and his first thought should be to equate this to the rate of loss of heat of the water ; the rate of flow of the water then follows.

As your correspondents imply, this is all rather naïve, but I hope that it is not "demonstrable nonsense." The candidates were given encouragement, by the instruction to "discuss any approximations," to show that they appreciated the limitations of their solution. If any of them had discussed the factors mentioned by your correspondents I should have been delighted, particularly if they had pointed out that they invalidated the elementary solution.

I think that the difficulty I have met in conducting this examination is that so few members of the Institute realize the peculiar problems involved in it. If one keeps to stereotyped or qualitative questions there is a fair chance that some students will be lucky and will be able to reproduce the answers without really understanding the subject. I have tried to avoid such questions. On the other hand, if one sets a question of the type that is now criticized, it may penalize the good student who tries to cope with complications the existence of which the poorer students do not even realize. I took the latter risk with, alas, the fair certainty that I would be safe (as, indeed, I was !).

I would not set a question of this sort in a university examination since one is usually meeting a much wider range of ability but, as far as the Graduateship examination is concerned, I am quite unrepentant.

Reviews of Books

A HISTORY OF SCIENCE

By George Sarton

London : Oxford University Press. Pp. xxvi + 554. Price 63s.

George Sarton is unique amongst those who have devoted their lives to a study of our heritage in the sphere of intellect. This book, just completed for press before his death on March 22, 1956, represents a stage, albeit an important one, in a bold enterprise the remainder of which must perforce fall to other hands, if indeed that should prove feasible. It will be hard to find ways and means of carrying forward the meticulous accuracy, combined with an engaging absence of pedantry which has always been a feature of Sarton's writing. As he says, he hopes that his readers will meet him half-way, when there is no perfect answer to the historian's dilemma.

This brings one to a natural acceptance of the vital characteristic of this volume, namely that the great story unfolds chronologically rather than strictly personally. Thus we have, Part I, the III Century B.C., Part II, the II and I centuries B.C. Consequently, one meets the same name several times over if its *floruit* extended accordingly. There is no drawback in that ; it even tends to stress how the labours of the outstanding figures were modified as experience widened, and the influence of outside contacts became increasingly marked. It needs recollection too that for the ancient world science and the liberal arts were bound together in a unity which subsequent specialization has largely obliterated. In these pages, it is not too difficult to see the fabric in the process of being woven, the strands of science (as we know it) and of letters interlacing and separating again as the centuries slip past.

It is all very human. Scholars who, in the opinion of the elect, had not wholly made the grade were classified as "beta." But this was largely the penalty of venturing into applied knowledge. Yet the danger was a very real one. By the time that creative Hellenism had invaded the rigid Roman mentality, there were people stupid enough to measure scientific prowess solely by its capacity to construct military machines, and to evolve gadgets. As if to anticipate this tendency well in advance, we have the disdain of Archimedes for his own ingenious devices. Before he was killed in 212 B.C. he had given mankind his results for the volumes of the sphere and the circumscribing cylinder (the ratio 2 : 3), and his astonishing premonition of the integral calculus, not to mention a close approximation to the value of π.

Much the same dispositions are appropriate in the case of Euclid, not only as a geometer, but as a physicist. What is remarkable is not so much the collection of thirteen books commonly associated with his name, but the method of presentation which represents once for all a mood of deductive principle, often (rightly) copied but never basically superseded. At least, his is the foundation of all natural philosophy, however great its improvements in analytical power.

Nevertheless, the glory of Euclid, as Sarton points out, is in his particular choice of the fifth (parallel) postulate. The same thing could be expressed—and has in fact been expressed—in several forms. Yet the one almost intuitively selected was the simplest, coupled with the stroke of genius which saw in it the need for proof simultaneously with the recognition that to supply it was impossible. Our author might have added that such perspicacity has had to wait until our own day for another case of insight of comparable depth, namely the enunciation by Gödel of the impossibility of proof in certain logistic systems.

The changing background of these majestic scenes is found to run true to type. Only too often, the quantitative results of ancient science were sadly wide of the mark. This was not wholly inherent : it came about partly because of a traditional disregard for the role to be played by technique. Oddly enough, that aspect of research had to wait a long time before it caught up with the power of theory. But the Hellenistic age had the right idea nearly every time, and over an amazingly wide field. Balance between thought and action, however, was not lacking, if the period is taken to comprise the three centuries combined. Vitruvius arose to complete his *magnum opus* on architecture, and thus to influence substantially the particular genius of the renaissance when the time was ripe. In England we have known his counterpart in Sir Christopher Wren, architect, mathematician and F.R.S.

Later chapters introduce the reader to a number of important topics like navigation at sea, the origin and development of the calendar and so on. On page 323 (footnote) appears an obvious slip—in discussing the ecclesiastical method of adjusting the odd day in a leap year (in February), St. Matthew is mentioned, whereas St. Matthias is obviously intended. But in general, the proof-reading must have been exemplary, both in the text and in the abundant references.

The reader would make a mistake if he imagined that this book set out to be a guide for the history of science in the narrow sense. It was, of course, the special contribution of these three centuries—so crowded with achievement—to advance not only knowledge of all kinds, but to make it available for man's use and enjoyment. Hence the invention for example, of the division between words in scripts, punctuation, anthologies and the rest.

In conclusion it may perhaps be mentioned that Volume I, by the same author (never reviewed in this *Bulletin*) dealt in the same masterly way with the "Golden Age," the age of Plato and Aristotle. It should be read and valued, as this book deserves to be. Dante chose Virgil as his guide : we cannot do better than follow George Sarton as our most distinguished cicerone.

F. I. G. Rawlins.

SANDWICH COURSES

By P. F. R. Venables

London : Max Parrish and Company Ltd. Pp. 160. Price 18s.

The rise of sandwich courses in recent years, as an alternative to the university mode of education of technologists, has been phenomenal. One main cause is the exceptional national need for scientists and technologists, but there are others more obscure. If, however, the reasons for the sudden development of these courses, half a century at least after their introduction into technical education, were obvious, we should still be curious as to why some of the educational problems associated with them have for so long remained unrecognized or unexplored.

Dr. Venables' book is an account, in characteristically vigorous style, of some of the attempts that have been and are being made to face and solve these problems, bringing with them changes and developments, that have made the last five years something of an adventure. No one working in this field is likely to underestimate their difficulty, or to imagine that complete or unique solutions have been found, but so much has happened and gone unrecorded that everyone will appreciate that the author has been able to document some of it at this early stage. There will naturally be a different book to write in another five or ten years.

In fact, there is a final chapter of this book with the heading " the next decade," which avoiding the " perils of prophecy " lists a series of questions—perhaps too many questions, but certainly including the major ones that trouble and excite us ; the selection of students, the content of the courses, examinations, industrial training and the integration of this with the education in the College. All these and others are discussed at some length earlier in the book.

Although there is some reference to Higher National Diploma courses, and a comment on craft courses, the book is mainly concerned with Diploma in Technology courses. It deals with these adequately, but with hardly enough recognition of what their introduction has done for technical education. Without them, few of the recent advances would have been possible. The middle chapter on Industrial Training is written by Mr. R. Ratcliffe, Deputy Controller of the Royal Ordnance Factories of the Ministry of Supply. It readily recognizes the conflict of opinion concerning the nature of the industrial training appropriate to technologists, comes down firmly for the retention of a five-year apprenticeship, and catalogues suggestions made recently by some of the professional engineering institutions. It pleads for college and industry to collaborate in producing " a joint agreed declaration of aim." This certainly is needed ; more than this is likely to emerge from some of the collaborative work now going on in a few colleges. Mr. Ratcliffe has nothing to say about the training of scientists, which incidentally raises many new and interesting problems. Indeed, one criticism of the book generally would be that it concentrates on the education and training of engineers, and makes no mention of courses for chemists, physicists, biologists and mathematicians.

It is surprising too in an account which is so progressive and forward-looking that there would seem to be a plea for the retention of courses for the external degree, and a gentle chiding of the Ministry of Education for action " designed to reduce university degree courses in technical colleges even to vanishing point." There are others outside the Ministry, in colleges and in firms, who have gladly lent their help. To some of us there seems a real danger that colleges, with external degree and Diploma in Technology courses, might well become schizophrenic.

However, with much that is written about general studies and a liberal education, about the problems of integration, about hostels, about student activities, there will be general agreement.

Perhaps it should be added that Dr. Venables does not like the term " sandwich course," which nevertheless he has taken as the title of his book. One suspects that the alternative he suggests and uses throughout, " industry-diploma " courses, is hardly likely to oust the present admittedly unattractive label.

J. Topping.

THE NEUTRINO

By James S. Allen

London : Oxford University Press. Pp. viii + 168. Price 36s.

The neutrino was introduced by Pauli as a postulate to save the conservation laws of mechanics in the description of β-decay processes. Since then physicists have employed the neutrino as a handy dust-bin in which to dump any scraps of energy, momentum or angular momentum left over from an otherwise neat and tidy reaction. As time elapsed, the consistency of the picture thus developed made it seem likely that the neutrino, though not yet directly observed, was one of Pauli's better ideas, and in 1952-6 the beautiful experiments of Reines and Cowan, showing reverse β-decay near a large fission reactor, raised the neutrino, for most of us, from postulate to particle. The present book must have been started at about this stage.

There remained several open questions about the nature of the particle. Was its rest-mass small, though finite, or strictly zero ? Were the neutrinos, emerging from nuclei in electron and positron emission respectively, the same particle, or related as particle and anti-particle ? What mathematical form had the interaction Hamiltonian of proton, neutron, electron and neutrino, fundamental for the theory of β-decay ? These questions were to be answered by careful experiments on β-emission, calling for a very high level of ingenuity and technique : Professor Allen has himself contributed a great deal to this field. The interpretation of these experiments was, however, erected on a set of postulates about the possible nature of the neutrino, one of which was on wheels. This book must have been largely written when Lee and Yang pulled it out. Allen then had the ungrateful task of re-arranging the debris while the new plan of the structure was still by no means clear. The resulting book is worth reading for several reasons. To obtain a clear picture of present beliefs about the neutrino, however, is not one of them.

The innovation of Lee and Yang is usually described as the recognition that parity is not conserved in certain natural processes, or more colloquially, that nature is screwy after all. If parity were conserved, this would imply that the reflection in a mirror of a physical system undergoing any natural process, if realized, would constitute an equally likely natural process. The simplest motions whose reflections are not congruent to themselves are screw motions ; so if we can find natural motions which are screws always of the one hand, we have found a complete failure of parity conservation. It now appears that the motion of the neutrino and anti-neutrino satisfies this condition : each travels with its spin axis perfectly oriented along the direction of travel, the neutrino screwing itself along with a left-handed, the anti-neutrino with a right-handed, action. In β-decay, neutrinos accompany positrons, and anti-neutrinos electrons ; this definition is chosen to conserve the number of light particles, the hope being that lepton conservation may be a rule of more general validity.

Although the theory of particles with this behaviour had been described already by Weyl in 1929, their identification as physical particles was hindered by this consideration : a particle of definite intrinsic chirality (helicity, or screwiness, are alternative terms) must have zero rest mass, unless we relax the requirements of the special theory of relativity. We can see this as follows. If a neutrino in left-handed flight has a finite rest-mass its speed is less than that of light, however high its energy, and we can imagine an observer overtaking it by accelerating on a parallel path. As his speed passes through that of the neutrino, he observes it first drawing away in left-handed flight, stopping, and then approaching in right-handed flight, since its velocity relative to him will have reversed without any change in spin. This transformation to the anti-particle by mere relative motion is inconsistent with the postulates of the special theory. (Note that this is an anthropomorphic classical picture of an inorganic quantal situation. The conclusion is, however, true).

Although this picture looks simple by hindsight, its construction was a major achievement. To disentangle the β-decay interaction was an equal task. Since, on the principle of sufficient reason (" Why should nature be left-handed ? "), the theoretical Hamiltonian to which the experimental results were being fitted had been set up assuming the conservation of parity, it was in principle unable to describe the facts. The workers in this field were being driven to suppose that the interaction of the four fundamental particles depended in a very odd way on their environment. They were not much helped by the fact that the crucial measurement of the β-decay of He^6, carefully made by Rustad and Ruby, gave quite unequivocally the wrong result. (Allen and his colleagues have since repeated the experiment and obtained results agreeing with the new theory. One hopes matters stay this way). The book under review describes the situation as it was when the theory was clearing up but the definitive experimental results were not yet to hand.

The book will be of value to workers interested in β-decay for its full survey of the important experimental work in the field up to mid-1957. People not familiar with present belief about neutrinos should read the more recent literature to fix their ideas so as to have a life-line through the book.

The book fails for most non-specialist readers because the theory whose results are quoted for experimental verification is not itself sufficiently described. Anyone with a clear head who enjoys seeing revolutions in progress will enjoy the book without worrying too much about its content. Undergraduate students wondering what research is about should look at it. I cannot recommend non-specialists to buy it, which is a pity, because the second edition, if there is one, will be an uncommonly good book.

G. Wyllie.

OPTICAL ASSESSMENT USING FREQUENCY RESPONSE TECHNIQUES. *Price 15s.*

TABLES OF OPTICAL FREQUENCY RESPONSE FOR THE CASES OF SPHERICAL ABERRATION AND COMA. *Price 5s.*

Technical Optics Section of Imperial College, London.

This is a summary in duplicated form of lectures delivered at the Summer School organized by Dr. H. H. Hopkins at Imperial College, London.

Dr. Hopkins writes on optical image assessment using frequency response techniques and on the calculation of frequency response from diffraction aberration theory. Methods of measuring the frequency response of an optical system are described by D. Kelsall and K. G. Birch. Transfer of contrast in the photographic process is discussed by H. Frieser (Technische Hochschule, Munich). E. H. Linfoot has contributed a section on information theory and its application to the quality-evaluation of optical systems. Television problems are discussed by W. N. Sproson (B.B.C.).

There are 134 quarto pages, plus diagrams, in the main volume, and tables and numerical values are included in the second volume. The treatment is suitable for a reader who has a general idea of the concepts involved and some acquaintance with Fourier transform mathematics.

I welcome this valuable publication with that kind of gratitude which is "a lively expectation of favours to come." I very much hope that Dr. Hopkins or Dr. Linfoot will write or edit a book which will include the present material together with a somewhat more leisurely introduction for the general reader.

R. W. DITCHBURN.

[*These publications may be obtained from The Technical Optics Section, Imperial College, London, S.W.7. Cheques should be made payable to Professor W. D. Wright, at that address.*]

MAGNETISM AND MAGNETIC MATERIALS

London: McGraw-Hill Publishing Co. Ltd. Pp. vi + 323. Price 77s. 6d.

In recent years magnetism has made tremendous progress, and is still expanding on a widening front. Not only this but the impact of this new expansion on technology has been even more remarkable. For the last few years conferences in the United States, planned with the intention of bridging the gap between the purely scientific and the industrial applications, have been held and are now an annual event. The promoters, not unjustifiably, consider the extent and number of the papers contained in the Conference Proceedings substantial evidence that the central aim is being accomplished.

The book under review consists of papers presented at the fourth Conference on Magnetism and Magnetic Materials held in November, 1958, at Philadelphia. As in previous years it is prepared as a supplement to the *Journal of Applied Physics* and the present report contains nearly 250 papers on a wide variety of magnetic topics classed under 15 sub-headings.

It is of course not possible to summarize such a wide and heterogeneous collection of contributions but certain features do stand out significantly. One of these, which commands a complete section of the papers, is that on computer components. Here ferrite toroids may be giving way to films and wrapped wires with decreased switching times reaching the milli-microsecond range. The subject of "micromagnetics" continues to develop with the emphasis moving from the configuration of domains to the dynamics of wall movement, where the important application lies in the origin of hysteresis losses. Neutron diffraction experiments on various types of magnetic material continue to attract attention, with single crystal investigations at low temperatures in the foreground, whilst the effects of irradiation on magnetic properties are covered in a small group of contributions.

Interest in both ferro- and ferri-magnetic resonance has not flagged, with line widths in some prominence. "Garnets and other compounds" constitutes a new and rapidly growing section, and work on the rare earth garnets bids fair to increase to a formidable degree, as these substances are in some ways simpler to the experimentalist and with other oxides more convenient to the theoretician than the metals, which continue to be intractable. A substantial number of papers deals with fine particles, the compelling interest being towards improved permanent magnet materials. Here the emphasis has shifted to anisotropy, both crystal as well as shape, and it is evident that considerable industrial effort is being directed towards practicable methods of efficient particle assemblies.

For all active workers in magnetism, whether experimental or theoretical, who wish to keep abreast of the rapidly developing facets of the subjects of magnetism, the contents of this book are essential, and as such carry strong recommendation.

W. SUCKSMITH.

INTRODUCTORY NUCLEAR THEORY

By L. R. B. Elton

London: Sir Isaac Pitman & Sons Ltd. Pp. xi + 286. Price 40s.

Dr. Elton's book should prove to be a most useful theoretical introduction to students beginning nuclear physics. It covers a wide range of topics, following the general pattern of Blatt and Weisskopf's *Theoretical Nuclear Physics*, with the addition of a final chapter describing the main features of the meson theory of nuclear forces. The first two chapters describe the properties of nuclei which the theories are required to explain, and introduce the important concepts of parity and isotopic spin. The later chapters contain a good deal of mathematics, as Dr. Elton has tried to avoid the phrase "it can be shown," and considers that he who does not work through the mathematics does not understand the physics. Insistence on rigour has resulted in clear expositions of, for example, effective range theory, the role of tensor forces in the ground state of the deuteron, and the Breit-Wigner formalism of resonance reactions. But mathematical completeness does not always lead to clarity. In the chapter on electromagnetic interactions, Dr. Elton achieves a complexity perhaps more appropriate to specialist works, whereas he is at his best in summarizing nuclear models, showing quite simply how the exclusion principle plays its important part in nuclear structure.

The cost of technial books is unfortunately always high. At 40s., *Introductory Nuclear Theory* is less expensive than many comparable books, and very good value—even for impecunious students.

I. S. GRANT.

APPLIED HYDRODYNAMICS

By H. R. Vallentine

London: Butterworth Scientific Publication. Pp. viii + 272. Price 50s.

This book is aimed at undergraduates in applied mathematics and undergraduates and postgraduates in engineering. I don't feel that it really meets the needs of the former because I think a quite different approach is needed for them and I have some reservations about the latter, perhaps unfairly since I haven't taught engineers myself.

The book gets full marks for the early introduction of the ideas of a real fluid and attempting to let the student see from the outset the limits imposed on ideal fluid theory. However, it is unfortunate that the elementary ideas of shear stress introduced in chapter 1 are not applied forthwith to such problems as Couette flow and flow under pressure between parallel walls. To introduce the full equations of flow in chapter 2 to deal with these problems is scarcely justified particularly when they are introduced on a " it can be shown that " basis.

How successful a single chapter can be in demarcating these limits is a matter for argument. I think the present one goes some way towards it without satisfying the mathematician's needs. The remainder of the book is concerned mainly with potential flow. Graphical, numerical and experimental analogy approaches to the solutions of Laplace's equation are introduced in chapter 3 ; chapters 4-7 are concerned with the standard methods of potential flow analysis in 2 and 3 dimensions with considerable emphasis on conformal representation in 2 dimensions.

L. HOWARTH.

News of Members

FELLOWS

G. L. J. Bailey has been appointed Superintendent of the Development and Research Department at Henry Wiggins & Co., Birmingham.

L. Bastings has been appointed Research Director at the Building Research Bureau, Wellington, New Zealand.

W. Betteridge has been appointed Superintendent of the Platinum Metals Research Department, The Mond Nickel Co. Ltd., Acton.

W. J. G. Beynon has been awarded the C.B.E.

Sir Lawrence Bragg is to give the Rutherford Memorial Lecture for 1960 : the lecture will be delivered in New Zealand.

J. R. Bristow has been appointed Head of the Department of Applied Physics in the Welsh College of Advanced Technology, Cardiff.

K. Deutsch has been appointed Principal Scientific Officer of the British Empire Cancer Campaign, Edinburgh.

J. V. Dunworth has been appointed Deputy Director of the Atomic Energy Research Establishment, Winfrith Heath.

I. Evans was recently appointed Assistant Director of the Mining Research Establishment, Isleworth.

P. S. Farago has been appointed Visiting Research Professor of the Department of Physics, University of Maryland, for one year.

J. H. Jaffe has been appointed Professor at The Weizmann Institute of Science, Rehovoth, Israel.

F. Llewellyn Jones is Acting Principal of the University College of Swansea.

W. O. Lock was recently appointed Research Associate to C.E.R.N., Geneva, for one year.

R. W. Parsons is now a Reader in Physics at the University of Queensland, Brisbane, Australia.

A. G. Peace is now Vice-Principal of Bolton Technical College.

J. Thewlis has been appointed Head of Scientific Staff Policy and Training Office, Atomic Energy Research Establishment, Harwell.

H. H. Watson has been appointed Director of the Canadian Army Operational Research Establishment.

F. W. G. White is the new Chairman of the Commonwealth Scientific and Industrial Research Organization of Australia.

D. A. Wright has been appointed Professor of Applied Physics in the University of Durham.

ASSOCIATES

A. Abbott was recently transferred to the post of Assistant Technical Manager, Courtelle Works, Courtaulds Ltd., Grimsby.

H. I. S. Allwood has taken an appointment in the Applied Physics Section of Shell Research Ltd.

D. E. Barnes has been awarded the O.B.E.

C. H. Barrow is a Lecturer in Physics in the University College of West Indies.

I. Brodie is a Senior Scientist at Westinghouse Electric Corporation, New York, U.S.A.

P. Chippindale has been appointed Senior Lecturer in Physics at the Royal Technical College, Salford.

R. Cockburn has been appointed Chief Scientist of the Ministry of Supply.

J. C. Cooper has been appointed Head of Cookstown High School, Cookstown, Co. Tyrone.

T. C. Common is Senior Mathematics Master at St. Austell County Grammar School for Boys.

L. J. Davies will join The Canadian Refractories Ltd., Marclan, Nr. Grenville, Quebec, Canada, in December.

S. H. Dunlop is now Vice-Master and Senior Science Master at Campbell College, Belfast.

B. Ellingham is a Physicist with Transparent Paper Ltd., Bury.

C. R. Evans has been appointed Manager of the Chemical Instruments Division, Servomex Controls Ltd., Crowborough.

J. Ewels is now at J. Stone & Co. (Deptford) Ltd., Crawley.

G. A. Fagan has joined H. S. Gellman & Co. Ltd., Toronto, Canada.

T. P. Flanagan has been appointed Head of Nucleonics Department, British Scientific Instruments Research Association, Chislehurst.

L. C. J. Fricker is now Project Manager at Clevite Ordnance, Washington, U.S.A.

E. Gillam has joined the staff of the Research Laboratories of the General Electric Co. Ltd.

P. Howarth is now a Physicist with the Group Research Laboratory, Reed Paper Group, Maidstone.

A. F. Howatson has been appointed Associate Professor in the Department of Medical Biophysics, University of Toronto, Canada.

H. Howells has been awarded the M.B.E.

W. C. Hynd is Manager of the Group Technical Development Department, Pilkington Brothers Ltd., St. Helens.

C. A. Jarman has been awarded the O.B.E.

D. John has been appointed Senior Lecturer in Physics at the Mid-Essex Technical College, Chelmsford.

E. T. Linacre is with John Brown Ltd., Leatherhead.

B. Love is a Reactor Physicist with the South of Scotland Electricity Board, Hunterston Nuclear Generating Station.

J. McCrickard is now Assistant Works Manager at Chapel Cross Works, United Kingdom Atomic Energy Authority, Dumfries.

D. G. Osborne has been appointed Lecturer in Physics at the University College of Ghana.

D. H. Pringle is Divisional Head of Nuclear Enterprises (G.B.) Ltd., Sighthill, Edinburgh.

A. G. Randell has been appointed Assistant Lecturer at The College, Swindon.

R. C. Ritchie was recently appointed Assistant Lecturer at Cambridge Technical College.

Miss Joan Margaret Tolliday of Akers Research Laboratories, I.C.I. Ltd., Welwyn, is now Dr. Joan Margaret Rowe.

D. H. Schultz has been appointed Optical Physicist and Optometrist at Laubman & Pank, Adelaide, South Australia.

M. Seal is a Section Head of the Research and Development Division, Engelhard Industries, Newark, New Jersey, U.S.A.

S. L. Seaton has been appointed Electronic Data Processing Consultant, United States Continental Army Command, Fort Monroe, Virginia, U.S.A.

J. J. Singh is now Assistant Professor of Physics at the Memorial University, St. Johns, Newfoundland, Canada.

L. Singh has been appointed Professor and Head of the Physics Department, S.B.R. College, Bilaspur, (M.P.) India.

E. E. Smith is Head of Development Laboratory, Standard Telephones & Cables Ltd., Paignton.

E. V. Stokes has been promoted to Group Captain, H.Q. Far East Air Force, Singapore.

J. W. Whigham has been appointed Senior Scientific Officer at the Admiralty Surface Weapons Establishment, Portsmouth.

R. H. Whittle is an Engineer in the Engineering Division, Atomic Energy Research Establishment, Harwell.

G. W. Wilson has joined the Westinghouse Electric Corporation Research Laboratories, Pittsburg, U.S.A.

B. Yates is now Senior Lecturer in Physics at Bradford Institute of Technology.

F. R. Young has been appointed Lecturer in Physics at Harrow Technical College.

GRADUATES

H. Baker is a Technical Officer at British Nylon Spinners Ltd., Pontypool.

W. C. Bolton is an Assistant Lecturer in Physics at the College of Further Education, High Wycombe.

D. R. Butler is now Assistant Research Physicist at the British Food Manufacturing Industries Research Association, Leatherhead, Surrey.

H. K. Chatterjee has been appointed Servo Engineer in the Electronics Apparatus Division, Associated Electrical Industries Ltd., Leicester.

K. J. B. Constable is Assistant Physics Master at Leeds Grammar School.

D. J. Cooper is on the staff of The Leeds College of Technology.

G. J. Davies is now Senior Scientific Officer at the Atomic Weapons Research Establishment, Aldermaston.

G. R. Froud is a Research Assistant in the Aeronautical Engineering Department, University of Southampton.

D. V. Harris has been appointed Project Engineer at the Recording Corporation of America, Moorestown, New Jersey, U.S.A.

R. P. Howson is now a Research Physicist with the Plessey Company Ltd., Caswell, Towcester.

C. L. Jones has taken an appointment at Redifon Ltd., Crawley.

S. Kaufman has joined the staff of the Department of Physics, Hebrew University, Jerusalem, Israel.

D. J. Lesford is now Scientific Officer at Services Electronics Research Laboratories (Admiralty), Harlow.

G. M. Musk has been appointed Technical Representative at Shell Chemical Company Ltd.

M. K. Myint has been appointed Lecturer in Physics at the University of Mandalay, Mandalay, Burma.

W. M. Pitt-Cooper is now at Associated Electrical Industries Research Laboratory, Aldermaston.

H. T. Shotton has joined the Dunlop Rubber Co. Ltd., Brasil.

Mrs. J. E. Simons has been appointed Assistant Physics Mistress at Luton High School for Girls.

J. B. Spencer is now a Scientist at Mullard Magnetic Components, Southport.

P. Swainston is a Physicist at the English Electric Valve Co. Ltd., Chelmsford.

J. M. Welland is a Development Engineer at Rotax Ltd.

R. F. Winspear has joined the Nuclear Health and Safety Branch, Central Electricity Generating Board.

The Institute's Journals

PRINCIPAL CONTENTS OF THE SEPTEMBER, 1959, ISSUES

Journal of Scientific Instruments : Volume 36, No. 9

Photoelectric double-slit interferometer for investigation of transparent thin solid films. By Lee Sang Soo.

The interferometer is of the Rayleigh two-slit type. A glass plate partly covered by the film to be measured is placed so as to cover one slit and the resulting fringe shift is a measure of the phase retardation due to the film. The shift is determined photoelectrically using a homodyne detection system to locate the fringe minimum. A sensitivity of $\lambda/7000$ is obtained.

Sensitive recording magnetic fluxmeter. By P. Lerond and Å. Thulin.

The fluxmeter described uses a taut-suspension galvanometer, the torque of which is compensated by positive feedback. This latter is furnished by a servo-operated potentiometer, the wiper of which follows the motion of the galvanometer light spot. The device is an adaptation of a commercially available recorder and permits recording of flux-variations as low as 100 Maxwell-turns per second.

Use of electric-current shims in the cyclotron. By J. H. Fremlin, F.Inst.P., W. Hardy and H. R. Shaylor.

The design and the method of construction of electric-current shims for the Birmingham cyclotron are described. Measurements are given showing the effects of these on magnetic-field distribution. Representative beam-current measurements are given which show that with shim-currents up to 500 A, the method was successful in making possible the acceleration of H^+ or $^3He^{++}$ ions with about the same efficiency as the D^+ ions for which the permanent steel shims were adjusted.

Use of scintillation counters in single crystal X-ray diffractometry. By P. J. Black and J. B. Forsyth.

The paper describes a scintillation counter apparatus used for single-crystal X-ray diffractometry. The variation of the signal/noise ratio with photomultiplier operating potential has been investigated for the Du Mont 6291 tube, and it is shown that the resolution of the signal pulses from the noise background improves as this potential is decreased. Signal resolutions of 26, 29 and 43% have been obtained with AgKα, MoKα and CuKα radiations respectively, the mean number of photoelectrons released per keV incident quantum energy being 6. Stability criteria which will help to ensure the overall uniformity in the counter response are suggested.

Method of amplitude control of a.c. signals. By J. B. Cornwall.

A circuit for controlling the r.m.s. value of an a.c. signal is analysed and practical results are discussed. The speed of response is such that for rates of change of 2·5% per second the output is controlled continuously within 1%. An alternative arrangement for maintaining, at a preset level, the peak value of repetitive pulses is also given.

Sensitive detector of γ-radiation in liquid or gaseous effluents. By J. G. Mitchell.

The instrument described is a plastic-phosphor scintillation-type detector which can be used to monitor the radioactivity of liquid and gaseous effluents. With liquid effluents, it can detect activities of about $1{\cdot}5 \times 10^{-6}$ μc/cm³ of 0·7 MeV γ-radiation, and for gaseous effluents, 1/280 m.p.c. of ^{41}A in air. The experimental determination of the optimum sensitivity of the detector system is described and results are given. The system provides a continuous day-and-night record of the activities monitored. Also, it gives automatic warning of dangerously high levels of activity and of a failure in its own electrical system.

New type of search coil for metal-pipe location. By J. A. Phillips, Grad.Inst.P.

A method of tracing metal pipes, involving the amplification of the voltage induced in a special type of search coil by transient currents injected into the pipe, is described. The search coil consists of two identical flat coils mounted side by side in the same plane, and so connected that the output voltage is equal to the difference of the voltages induced in the two coils. An audible signal is obtained in headphones after amplification of the output voltage. It is found that, with this twin coil system, the signal strength varies approximately as $1/R^2$, where R is the perpendicular distance from the pipe to the search coil, and that a more reliable performance is obtained compared with the usual single type of search coil.

Vibration amplitude meter using moiré-fringe technique. By T. W. Aitchison, J. W. Bruce and D. S. Winning.

The instrument described, though not being the answer to all vibration-measuring problems, has characteristics which make it ideal for the measurement of vibration amplitudes at frequencies below 50 c/s and for the calibration of other transducers. Also, because its frequency range extends down to zero, the instrument can be used to detect and measure small displacements.

Grating spectrophotometer for the Schumann ultraviolet range. By F. J. P. Clarke, A.Inst.P., and W. R. S. Garton.

Constructional and performance details are given of a photoelectric spectrophotometer erected for the measurement of the optical transmittances of small solid specimens, in the range above 900Å. The instrument incorporates a one-metre radius, 600 lines/mm concave grating, and scanning of the spectrum across the exit slit is performed by a linear movement of the centre of the Rowland Circle. The mechanical and electrical arrangements permit rapid measurements, quick exchange of specimen and the direct reading of transmittance on a 0–100 scale.

British Journal of Applied Physics : Volume 10, No. 9

CONFERENCE REPORT

Summarized proceedings of a symposium on current developments in the production of high vacua—London, April, 1959

At a symposium organized by The Institute of Physics and held in London, on 17 April, 1959, the first session was devoted to getter-ion and ion-sorption pumps, the second to the production of high vacua in large equipment, and the third to short contributions on the analysis of residual gases in kinetic vacuum systems.

SPECIAL ARTICLE

Dense electron beams. By B. Meltzer, F.Inst.P.

The industrial context of electron beam design is sketched. The theoretical assumptions of classical trajectory behaviour and laminarity are discussed. Langmuir's diode analyses,

Pierce's design method and Brillouin's magnetic collimation are described, as well as recent studies of the Pierce-Cauchy problem and self-magnetic effects in simple beams. Summaries are given of the conservation principles of beam dynamics, use of the action function in analysis and design, the position as regards computation, and some recent progress.

Bulb breaking correction for heats of wetting determinations. By R. C. Gallavan.

Some factors affecting the heat generated when an evacuated glass bulb is broken in water at 25°C have been studied using a calorimeter of high sensitivity. The importance of the gaseous content of the water in the calorimeter is illustrated by deliberate variation of the carbon dioxide content. By careful control of factors discussed, heats of breaking have been measured that are reproducible to ±0·005 J of the mean value.

Application of delayed feedback in electronic circuits. By Zs. Naray.

By the use of suitable delayed feedback (d.f.b.) from the output terminals of a four- (or two-) pole network to the input, a great variety of different signals can be generated, the shape of which is determined by the characteristics of the four- (or two-) pole network, the d.f.b. loop and, under certain conditions, by the shape and duration of the trigger signal which is needed to set the d.f.b. system in operation. Two simple applications of delayed feedback in electronic circuits (where the loop gain is real and equal to or less than unity) are given :

(*a*) The output of a phase-inverting amplifier (amplification, $-g$) is fed by a delay line (delay time τ) to the input of the amplifier. If $|g| v \simeq 1$ (where v is the loss in the d.f.b. loop), periodic signals of frequency $f \simeq 1/2\tau$ are generated.

(*b*) If, in the same arrangement as (*a*), $|g| v < 1$, an output signal is produced only if a trigger signal is fed into the d.f.b. loop ; that is, the circuit works as a triggered oscillator of frequency $f \simeq 1/2\tau$. Because of mixing (additive or multiplicative) between the trigger signal of duration T and the d.f.b. signal, the shape of the output signal depends on the value T/τ.

By investigation of the output signal with a frequency meter or oscilloscope, the delay time of an unknown element (e.g. delay line, amplifier) connected in the feedback loop can be measured. The d.f.b. oscillators have a frequency stability of about 10–5/h.

Dielectric properties of water/alumina. By J. L. Wood.

The real and imaginary components of the dielectric constant of activated alumina powder containing various quantities of water have been measured at temperatures from 0–29·8°C, and at frequencies from 40 c/s to 100 Mc/s. The loss observed in this frequency range is ascribed to a Wagner-type mechanism. No discontinuity in the dielectric properties of the medium was observed.

Powder technique for the empirical determination of absorption corrections. By H. A. Richard Wegener.

The X-ray absorption factors necessary in the accurate determination of intensities in X-ray diffraction structure analyses can be obtained empirically by an analogue technique. This is accomplished by replacing the single crystal in its camera by a powder specimen of the same shape, macroscopic orientation and absorption properties, and recording the pattern as the camera goes through the same motions as performed before with the single crystal. The patterns arising in conjunction with different cameras are described, the correction factors necessary are pointed out, and the technique of finding relative and absolute absorption factors with the help of a pattern having calculable absorption factors is elucidated. In the appendix, the correction factors peculiar to this technique are derived analytically.

Cathode emission measurements in low pressure discharges. By Miss A. D. Forster-Brown, Grad.Inst.P., and M. A. Cayless, A.Inst.P.

A method described in an earlier paper for measuring the zero field emission from hot cathodes in discharges is compared with that of the probe methods described by C. G. Found. Good agreement is obtained, thus supporting the interpretation of the measured characteristics. It is shown how this method may be applied to measure the emission from cathodes in ordinary long discharge tubes, such as fluorescent lamps, without the necessity for inserting probes or interfering with the construction of the tubes or electrodes in any way.

Use of an integrating sphere to distinguish between absorption and scattering in solids. By J. A. Bastin, E. W. J. Mitchell, A.Inst.P., and J. Whitehouse.

In transmission measurements on plane-parallel specimens, light might be lost by absorption or scattering. A method is described in which measurements are made with the same plane-parallel specimen in an integrating sphere. Comparison of the two sets of results allows a quantitative distinction to be made between absorption and scattering. The method is illustrated by some measurements on quartz and diamond.

Attenuation of light by wood smoke. By W. W. Foster, A.Inst.P.

On the basis of experimental observations of the optical properties of wood smoke particles in bulk and in their natural form as spherical droplets, it is shown theoretically that the attenuation of light by wood smoke results mainly from scattering by the droplets, the effects of absorption being negligible. Other experimental observations on the effective optical density of wood smoke up to high mass concentrations lead to a calculation of the mean effective radius of the wood smoke particles. The Lambert-Beer law appears to hold over the whole experimental range, in accordance with a theoretical estimate of its limits of validity for the conditions used.

The X-ray scanning microanalyser. By P. Duncumb.

The chemical microanalysis of a surface by the Castaing technique is carried out by exciting characteristic X-ray emission from a selected point, located optically under a stationary electron beam about 1 μ in diameter. In many cases, the speed of working is greatly increased by the use of a scanning technique, which enables the surface distribution of a given element to be presented visually as an image on a cathode-ray tube screen. For quantitative analysis of a selected feature accurate positioning of the beam may be carried out by reference to this image, or to a similar image showing topographical detail. The method has been applied to elements of atomic number 12 and above, in metallurgical, biological and mineralogical specimens.

The paper deals with the principle, theory and design of an X-ray scanning microanalyser, and typical applications are illustrated by two examples.

Commonwealth of Australia Repatriation Department

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Applications are invited from qualified persons for permanent appointment to vacancies existing in the above categories.

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(*d*) **THE SOLID STATE** section is a new one and the successful applicant will be required to take an active part in the recruitment of staff and in the formulation of a research programme on such topics as dielectric conduction, refractory semi-conductor materials and high power semi-conductor devices.

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Applications, giving full details of experience and qualifications, should be sent to Dept. C.P.S., Marconi House, 336/7 Strand, London, W.C.2, quoting reference 1513G.

PHYSICIST, MECHANICAL OR CHEMICAL ENGINEER required at Explosives Research and Development Establishment, Ministry of Supply, Waltham Abbey, Essex, to lead small team on experimental studies of Heat Transfer Phenomena at very high temperatures and high velocities, and on physical properties of materials at extreme temperatures. Excellent opportunity for individual research in this relatively new field. Appointment in grade of Senior Scientific Officer. Salary £1,233 – £1,460. Minimum age 27. Superannuation under F.S.S.U. First or second class honours degree and at least three years postgraduate research experience required. Housing may be available within reasonable time for married man. Forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1 (quoting A.406/9A).

APPLIED CHEMISTS AND PHYSICISTS

British Nylon Spinners Ltd. invite applications for vacancies caused by the extension of their Research and Development activities at their Pontypool headquarters. Those men who have not only a good academic qualification in chemistry or physics and, for preference, some postgraduate experience but also have a desire to use their training and see their energies directed to obviously useful ends, should find the work of unusual interest. The objectives can only be properly pursued in co-operation with commercial staff and with other industries, and therefore there will be plenty of opportunity for the exercise of personal qualities and for the demonstration of initiative and willingness to accept responsibility. Conditions of employment are attractive and in line with the best available in industry to-day, and the Company's premises are in unexpectedly delightful countryside in a rural area, with good communications providing the best of town, sea and country. Housing presents little real difficulty, and the Company gives considerable assistance to new staff in resettling their families. Applications should be addressed to the Personnel Manager, British Nylon Spinners Ltd., Pontypool, Monmouthshire.

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A vacancy exists for an honours graduate physicist to work on radiation effects in solids. The Department is equipped with a 2 MeV electron accelerator which is being used entirely for work in this field. Applicants should preferably have had two years' research experience but this is not essential. Opportunities exist for reading for higher degrees. The salary will depend on experience. Applications, including the names of two referees, should be submitted, as soon as possible, to Professor R. W. Ditchburn, Physics Research Laboratory, The University, Upper Redlands Road, Reading, Berks.

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